Rolling Stone Lake

Langlade County, Wisconsin

Comprehensive Management Plan

September 2012

Sponsored by:

Rolling Stone Lake Protection and Rehabilitation District

WDNR Grant Program

LPL-1251-09 and LPL-1256-09

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Onterra, LLC
Lake Management Planning

Rolling Stone Lake

Langlade County, Wisconsin

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Acknowledgements

This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Rolling Stone Lake Planning Committee

Sonny Wreczycki	Char Waite	Lance Goetzman
Mike Sadler	Brent Radobicky	Ted Jacobsen
Tim DeShaney	Sue DeShaney	Gerald Mijal

Wisconsin Dept. of Natural Resources

Jim Kreitlow
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1.0 INTRODUCTION

Rolling Stone Lake, Langlade County, is a 682-acre drainage lake with a maximum depth of 12 feet and a mean depth of 6 feet. This eutrophic lake has a relatively large watershed when compared to the size of the lake. Rolling Stone Lake contains 27 native plant species, of which fern pondweed is the most common plant. Curly-leaf pondweed is known to exist in the lake.

Field Survey Notes

A scenic, fertile lake with mucky substrate and an abundance of aquatic plants. Much natural shoreline observed on the northern side of the lake.

Photograph 1.0-1 Rolling Stone Lake, Langlade County

Lake at a Glance – Rolling Stone Lake

Morphology	
Acreage	682
Maximum Depth (ft)	12
Mean Depth (ft)	6
Shoreline Complexity	1.8
Vegetation	
Curly-leaf Survey Date	June 8, 2009
Comprehensive Survey Date	Aug 28-Sept 3, 2007
Number of Native Species	27 (including incidentals)
Threatened/Special Concern Species	-
Exotic Plant Species	Curly-leaf pondweed
Simpson's Diversity	0.86
Average Conservatism	6.3
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.5
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	13:1

Because of the presence of aquatic invasive species (AIS) in many nearby lakes (the downstream Pickerel Lake is within one mile and contains EWM), the Rolling Stone Lake Protection and Rehabilitation District (RSLPRD) chose to adopt a proactive strategy to protect their lake from this threat. During the course of this project, it was confirmed that curly-leaf pondweed inhabits the lake, and is likely a recent infestation. The only other aquatic invasive species (AIS) known to exist in Rolling Stone Lake is the rusty crayfish.

Rolling Stone Lake's shallow depth and dense aquatic vegetation population are major concerns of the RSLPRD. Currently harvesting activities are used to increase recreational opportunities and remove excessive amounts of plant materials which have can attribute to low winter dissolved oxygen levels.

The RSLPRD originally elected to complete the planning program for three main reasons: 1) to learn whether exotic plants occur in their lake, 2) to formulate an ecologically sound harvesting program that meets stakeholder's interests, and 3) to understand their lake ecosystem more fully. The data collected from the surveys involved within this project will serve as a baseline set of data for which future management planning projects can call upon. Therefore, this project is important not only in the management and protection of the lake, but also in its likely restoration.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and updates within the lake group's newsletter.

The highlights of this component are described below in chronological order. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting
On June 13, 2009, a project kick-off meeting was held at the P & R District building. The presentation's purpose was to introduce the project to lake association members and the general public alike. The meeting was announced through a mailing and personal contact by Rolling Stone Lake P & R district members. The attendees were informed about the events that led to the initiation of the project. A presentation was given by Tim Hoyman that started with an educational component regarding general lake ecology and ending with a detailed description of the project including opportunities for stakeholders to be involved. Mr. Hoyman's presentation was followed by a question and answer session.

Stakeholder Survey
During April of 2009, an eight-page, 33-question survey was mailed to 393 riparian property owners in the Rolling Stone Lake watershed. 49 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Rolling Stone Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting I
On July 15, 2010, Tim Hoyman of Onterra met with several members of the Rolling Stone Lake Planning Committee. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many concerns were raised by the committee, including nuisance levels of native aquatic plants, as well as the presence of curly-leaf pondweed.

Planning Committee Meeting II
On March 18, 2011, Tim Hoyman of Onterra met with members of the Rolling Stone Lake Planning Committee once again. During this meeting, the project conclusions were reviewed,

and then the group began to develop an Implementation Plan for Rolling Stone Lake. During this brainstorming session, challenges were identified, as well as realistic goals set in order to address those challenges. Mr. Hoyman directed the meeting while the Planning Committee addressed the primary concerns of water quality, curly-leaf pondweed, and mechanical harvesting plans.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected on Rolling Stone Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Rolling Stone Lake's water quality analysis:

> **Phosphorus** is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al. 1994, Dinius 2007, and Smith et al. 1991).

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: Oligotrophic lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. Eutrophic lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. Mesotrophic lakes fall between these two categories.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a more clear understanding of the lake's trophic state while facilitating clearer long-term tracking. Carlson (1977) presented a trophic state index that gained great acceptance among lake managers.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some macrophytes within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

> **Lake stratification** occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The epiliminion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fish kills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading In lakes that support strong stratification, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 μg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 μg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist; 1) shoreland septic systems, and 2) internal phosphorus cycling.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Rolling Stone Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: **shallow (mixed)** or **deep (stratified)**. Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.
>
> > Headwater drainage lakes have a watershed of less than 4 square miles.
> >
> > Lowland drainage lakes have a watershed of greater than 4 square miles.

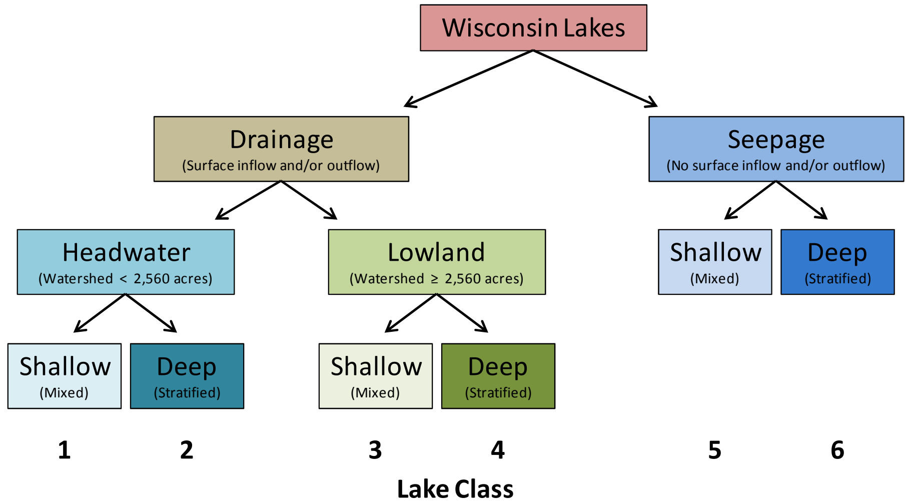

Figure 3.1-1. Wisconsin Lake Classifications. Rolling Stone Lake is classified as a shallow (mixed), lowland drainage lake (Class 3). Adapted from WDNR PUB-SS-1044 2008.

Lathrop and Lillie developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). **Ecoregions** are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Rolling Stone Lake is within the Northern Lakes and Forests ecoregion.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements in terms of water quality under the Clean Water Act (WDNR 2009). It is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. This method incorporates both biological and physical-chemical indicators to assess a given waterbody's condition. In the report, they divided the phosphorus, chlorophyll-*a*, and Secchi disk transparency data of each lake class into ranked categories and assigned each a "quality" label from "Excellent" to "Poor". The categories were based on pre-settlement conditions of the lakes inferred from sediment cores and their experience.

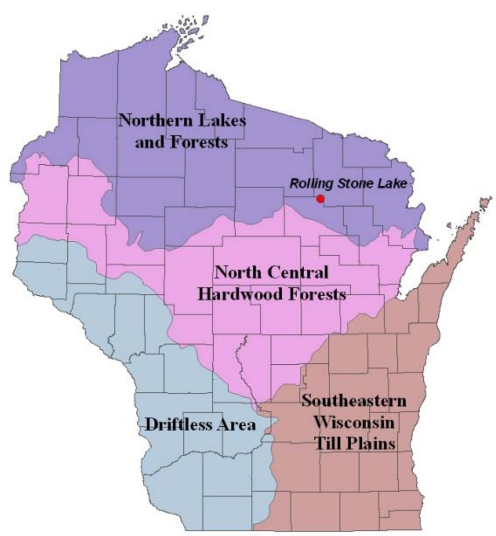

Figure 3.1-2. Location of Rolling Stone Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Rolling Stone Lake is displayed in Figures 3.1-3 - 3.1-7. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Private Onsite Wastewater Treatment Systems

Improperly maintained or faulty septic systems may impact both the health of individuals using the lake and also the water quality of a lake. A properly operating system will remove most disease-causing pathogens, but may not remove or treat nutrients such as phosphorus or nitrogen entirely. Besides the obvious health concerns, leaky septic systems may contribute nutrients to a lake, which can promote algae and aquatic plant growth.

The Wisconsin Department of Commerce oversees private onsite wastewater treatment systems (POWTS) through Chapter Comm 83. Although there are an estimated 760,000 to 790,000 private septic systems located in the state of Wisconsin, the exact number and location of these systems is unknown. Recent legislation has prompted counties to develop a comprehensive inventory of their septic systems. This inventory has a statutory deadline of October 1, 2013 (Comm 83.255(1)(a), updated through 2009 Wisconsin Act 392). Currently, it is believed that the statewide POWTS inventory is about 75% complete.

Creating an inventory of POWTS throughout the state of Wisconsin is important, but maintaining these systems so that they operate correctly is critical. The enacted legislation has developed rules that establish a maintenance program for private sewage systems, and even encourages failing system replacement and rehabilitation through a funding program called the Wisconsin Fund. A condition for a county to participate in this program is that the county must adopt and implement a maintenance program, and must do so by the state-wide deadline of October 1, 2015. Because each program is governed on a county basis, the local health or zoning and planning department will be able to inform residents on the maintenance program and funding opportunities in their respective county.

It is generally recommended that POWTS are pumped or inspected every three years for proper functioning. Between inspections, there are several ways to determine if your septic system may require maintenance:

- Sewage has backed up in your drains, toilets or basement
- Drains begin to run slower than normal
- Wet areas or bright green grass appear over the drain field
- A dense colony of aquatic plants or algae appears near your shoreland
- Bacteria or nitrates are found in your well water
- Biodegradable dye flushed through the system appears in the lake or stream

Additionally, there are many ways to keep your septic system in top shape, and reduce the chances of system failure:

- Have your system inspected on a regular basis (every 3 years is recommended)
- Avoid driving or parking vehicles on the drain field
- Do not dispose of materials in drains that enter the septic tank. These items (fats, grease, paper towels, disposable diapers, sanitary napkins, etc.) may clog the septic tank and other items (cleaning fluids, oils, paints, etc.) may not be treated and end up in groundwater.

In 1991, a survey of sanitary systems on lots surrounding Rolling Stone Lake was started and then completed in 1996. It was done in three phases – first, the riparian owners were surveyed. Then, outlying lots were surveyed. Finally those lots farthest from the lake were surveyed. Out of approximately 125 lots involved in the survey, 51% of the systems failed. The Langlade County Zoning Office, who was involved in the study from the beginning, oversaw efforts to replace all of these failing systems.

Rolling Stone Lake Water Quality Analysis

Rolling Stone Lake Long-term Trends

In the past twenty years there has been a considerable amount of water quality data collected from Rolling Stone Lake. This has been the result of state, federal, and local government as well as citizen volunteer involvement in monitoring the health of the lake. Long-term datasets allow managers a chance to objectively analyze an ecosystem, as opposed to relying only upon anecdotal accounts of changes in water quality, which may be unintentionally biased.

Total phosphorus has been measured in Rolling Stone Lake annually since 1986, with multiple samples being taken per year. These annual summer averages range between categories of “Excellent” to “Fair”, and a weighted average across years fall into the “Good” category (Figure 3.1-3). This weighted summer average is comparable to similar lakes across the state. As seen in Figure 3.1-3, the phosphorus in the lake fluctuates on an annual basis. As mentioned in the Watershed section, Rolling Stone Lake has a fairly large watershed to lake area ratio which influences the nutrient content in the lake greatly. It is likely that climatic factors such as precipitation influence the nutrient content of the lake substantially.

Chlorophyll-*a*, like total phosphorus, has also been measured annually in Rolling Stone Lake since 1986. These annual summer averages fluctuate between categories of “Excellent” to “Fair”, while a weighted average falls into the “Good” category (Figure 3.1-4). This weighted average is slightly higher than the median value for similar lakes statewide. Similar to the phosphorus dataset, averages in chlorophyll-*a* have fluctuated in the past 20 years. The values coincide very closely with the phosphorus data; in years which high phosphorus was measured, chlorophyll-*a* was also found to be fairly high (see Figure 3.1-4, years 1998, 2002, and 2009 as examples). As previously mentioned, phosphorus and chlorophyll-*a* are highly related to each other as phosphorus is often the primary nutrient responsible for algal production (and thus chlorophyll-*a* concentration in the water). As discussed further below, the relationship between these two variables and Secchi disk clarity is also correlated, and is illustrated well in the Rolling Stone Lake dataset.

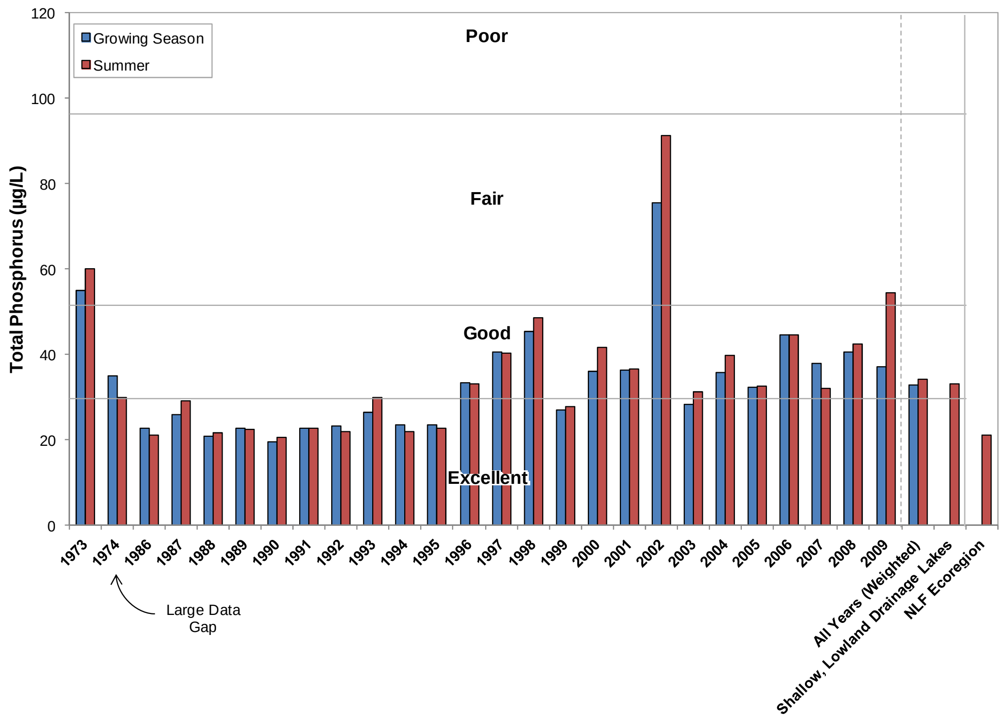

Figure 3.1-3. Rolling Stone Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

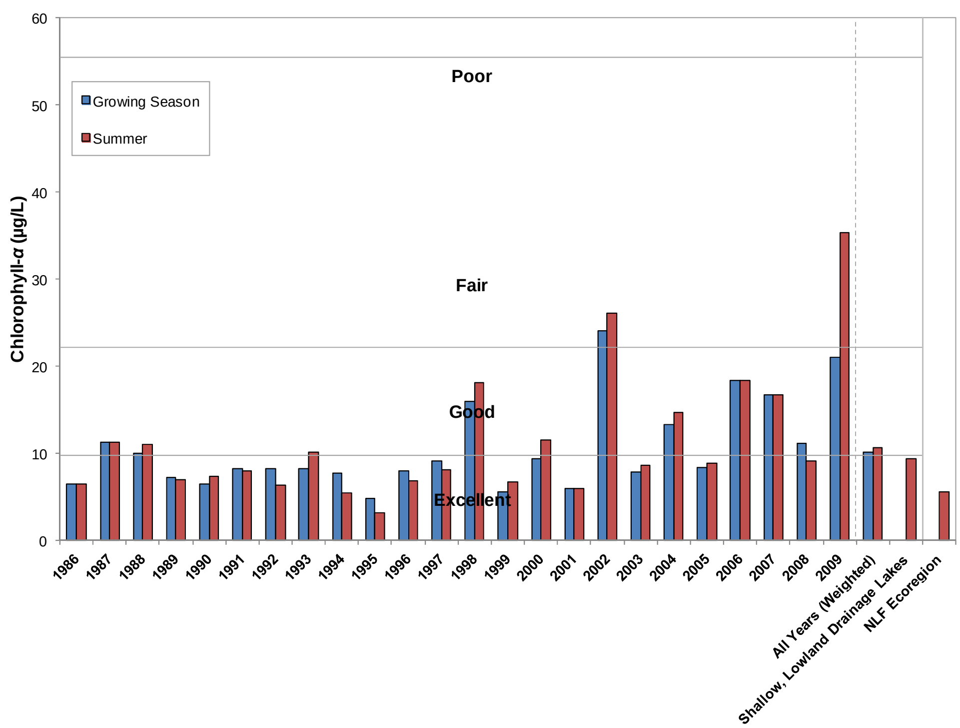

Figure 3.1-4. Rolling Stone Lake, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Secchi disk clarity has also been measured consistently since the late 1980's in Rolling Stone Lake. Annual summer average depths range from 3.2 to 9.3 feet while a weighted summer average over these years measures at 6.7 feet (Figure 3.1-5). These measurements range in categories of "Fair" to "Excellent", while the weighted average is "Excellent" and is slightly higher than the median value for similar lakes statewide. As previously mentioned, Secchi disk clarity is highly tied to chlorophyll-*a* as algal abundance in a lake influences the clarity of its waters. It is not surprising then to see large fluctuations in Secchi disk readings over the same time period in which chlorophyll-*a* was measured. In years of higher algal biomass (e.g. 1998 and 2002) the clarity of the water decreased, as indicated by the lower Secchi disk measurements.

It may appear at first that there is a slightly decreasing trend in the water quality of Rolling Stone Lake. However it is important to note several factors which may influence bias on this judgment. First, it is likely that these parameters are influenced heavily by variations in climatic conditions. Particularly, precipitation has a large impact on lake nutrient content (which in turn influences algae and water clarity). State climatologists agree that the north region of Wisconsin is currently experiencing drought conditions, which have persisted over the past 8 years. While these conditions have existed over the long-term (8 years), annual variations in precipitation have still occurred. For example, in summer of 2002 the Northeast region of Wisconsin received approximately three more inches of precipitation than that of the past 100 year average. This may be responsible for an increased phosphorus load to Rolling Stone Lake, which would in turn influence algal growth and water clarity. Secondly, the timing of sampling would influence sample concentrations as well. If samples were collected following a heavy rainstorm by only several days, the concentrations of nutrients and chlorophyll could be temporarily higher than normal and not necessarily representative of the conditions in the lake over the entire growing season. Finally, the morphology of the lake may influence sample concentrations as well. Large, yet shallow lakes, such as Rolling Stone Lake, are easily mixed by summer winds (this is discussed further in the Dissolved Oxygen and Temperature paragraphs below). If sampling occurs while the lake is undergoing mixing, phosphorus-bound sediment and periphyton particles may be collected off the bottom of the lake and influence these values.

Overall, the water quality of the lake has changed little in the past 20 years. While annual variations in the water quality have occurred, there is little evidence supporting a substantial change in either direction of better or worse.

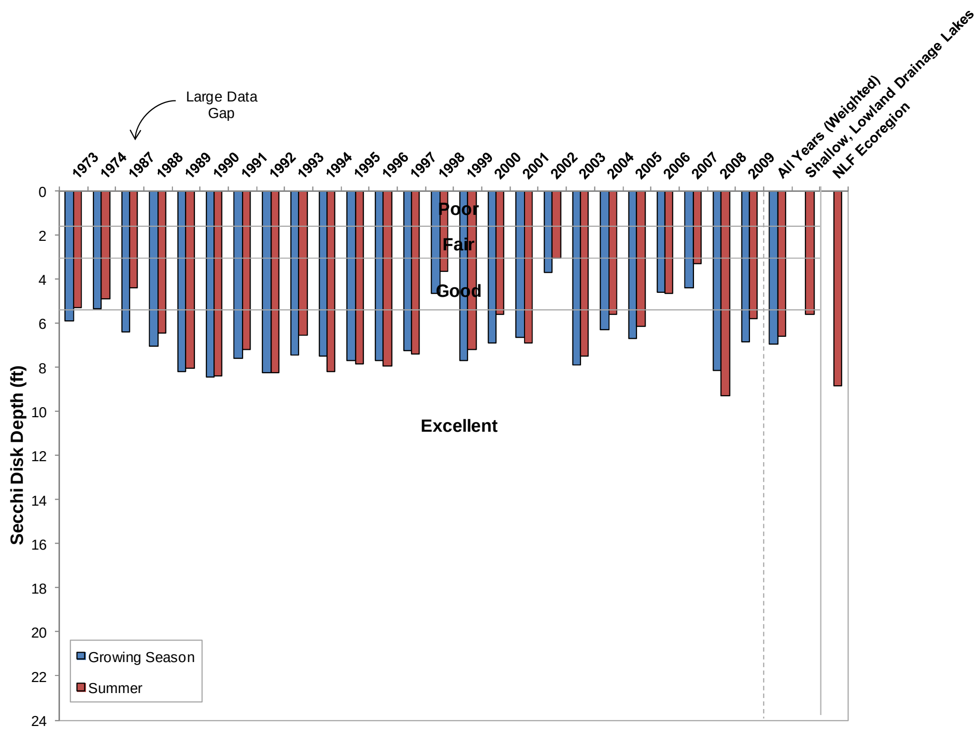

Figure 3.1-5. Rolling Stone Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Rolling Stone Lake

Using midsummer nitrogen and phosphorus concentrations from Rolling Stone Lake, a nitrogen:phosphorus ratio of 25:1 was calculated. This finding indicates that Rolling Stone Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Rolling Stone Lake Trophic State

Figure 3.1-5 contain the WTSI values for Rolling Stone Lake. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from middle eutrophic to middle mesotrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* WTSI values, it can be concluded that Rolling Stone Lake is in a moderately eutrophic state.

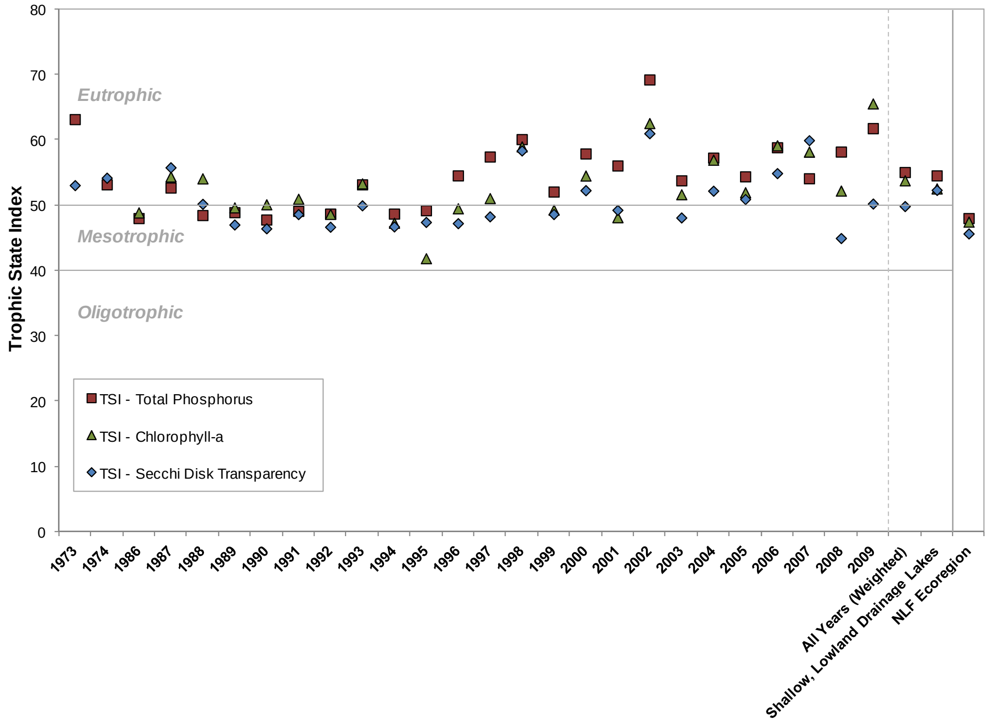

Figure 3.1-6. Rolling Stone Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Rolling Stone Lake

Dissolved oxygen and temperature data were collected in 2009 and 2010 by several groups including Onterra staff, Rolling Stone Lake CLMN (temperature only), and the WDNR. Profiles displaying these data are located below (Figure 3.1-7).

In winter of 2009, the lake was thermally stratified from top to bottom. This occurs naturally in Wisconsin lakes. As ice covers the lake, the coldest water temperatures are near the ice layer while the denser, warmer water sinks to the bottom of the lake. During this time, dissolved oxygen was measured at just over 5.0 mg/L near the surface, and dropped below 1.0 mg/L at 5 feet. Similarly, oxygen approached 1.0 mg/L at 6 feet in March of 2010. WDNR fisheries biologists believe that sport fish can usually handle low dissolved oxygen levels under the ice, even for weeks at a time. Fish may sustain levels as low as 1.0 mg/L for 2-3 weeks. Most fish kills seem to affect small panfish, as they have smaller "home" ranges and are less likely to move to find better water or have the experience to know where it find it as with larger fish.

In March of 2010, dissolved oxygen data was collected at a central deep hole, as well as near two tributary stream inlets. The oxygen levels were considerable better than those measured in 2009, and the levels near the inlet streams were better yet, indicating that "safe" zones of higher oxygen exist within the lake. Because Rolling Stone Lake is fairly shallow, it is easily mixed by winds occurring in the open water season. This likely helps keep oxygen well distributed in the lake. Indeed, throughout the summer months oxygen remained sufficient in the water column (between 7.0 and 8.0 mg/L when mixed). When this mixing action is removed, dissolved oxygen and temperature will decrease in the deeper portions of the lake, as is observed in the data collected during July 20th, 2009 (Figure 3.1-7). The substantial decrease in oxygen is due to the decomposition of organic matter which has settled to the bottom of the lake, and is a naturally occurring process.

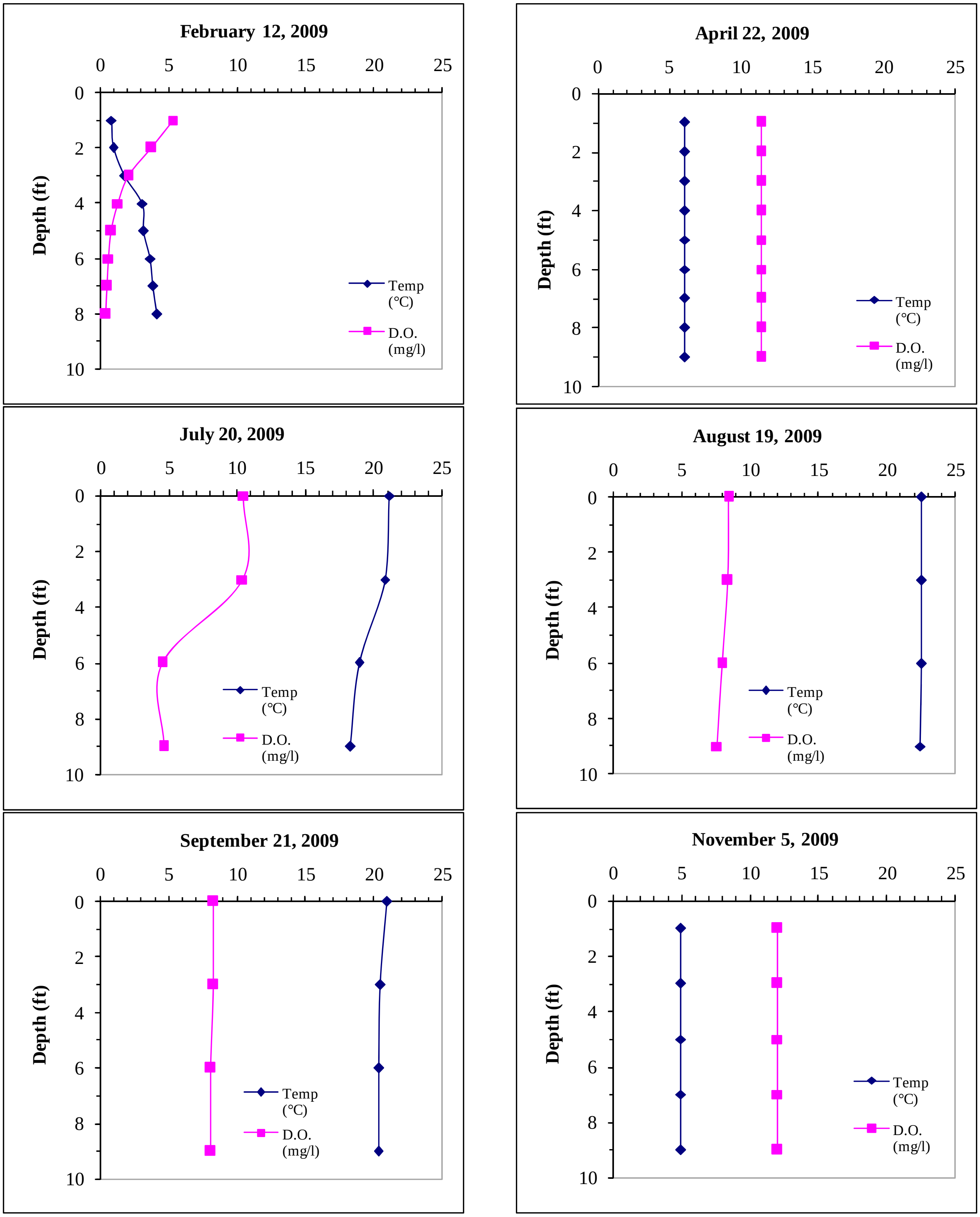

Figure 3.1-7. Rolling Stone Lake dissolved oxygen and temperature profiles.

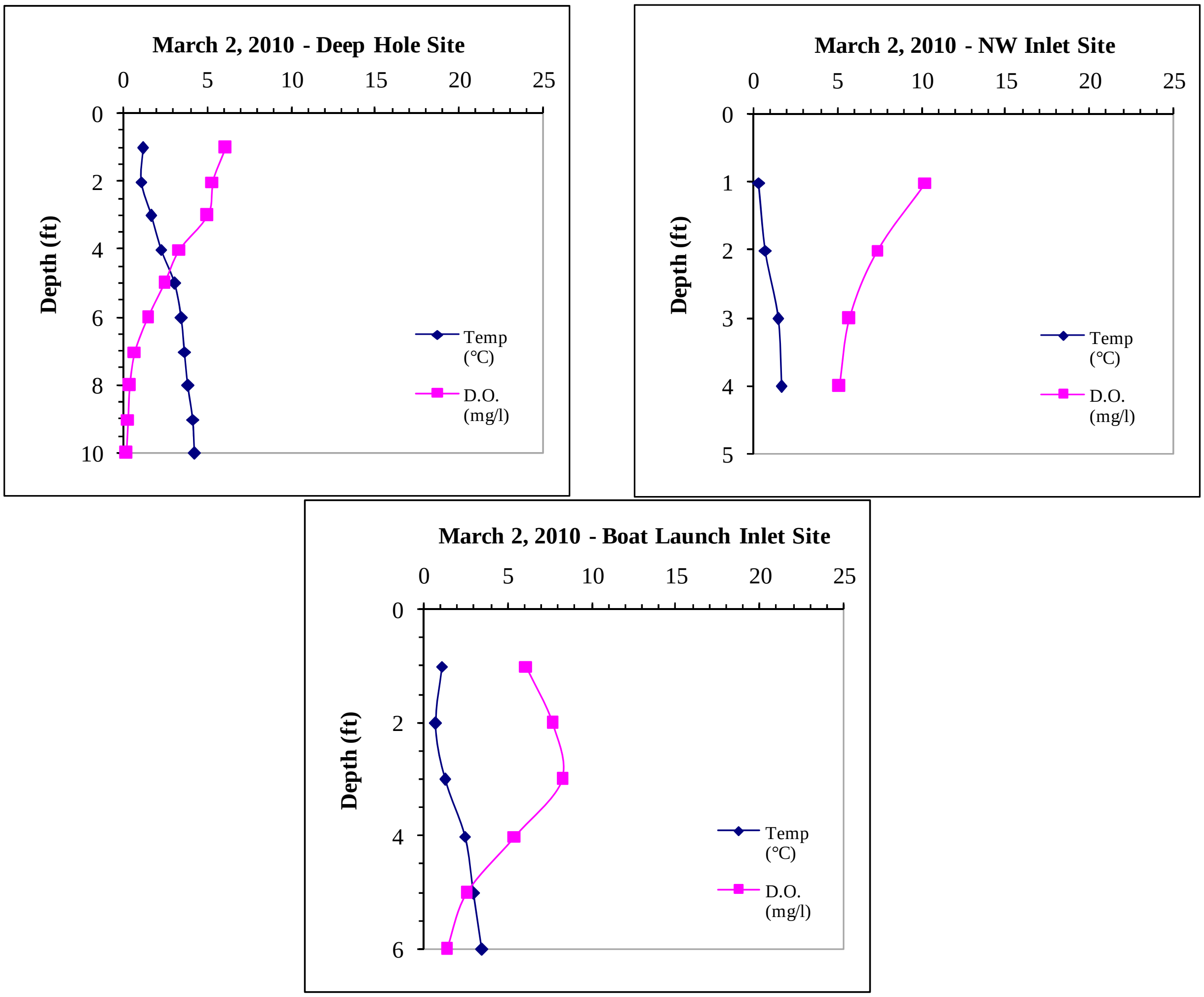

Figure 3.1-7 (continued). Rolling Stone Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Rolling Stone Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Rolling Stone Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The pH of the water in Rolling Stone Lake was found to be above neutral with a value of 8.5, and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Rolling Stone Lake was measured at 93.0 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has no sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Rolling Stone Lake's pH of 8.5 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Rolling Stone Lake was found to be 22.7 mg/L, falling within the optimal range for zebra mussels.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Rolling Stone Lake is considered suitable for mussel establishment.

3.2 Watershed Assessment

A lake's **flushing rate** is simply a determination of the time required for the lake's water volume to be completely exchanged. **Residence time** describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those exceeding 10-15:1, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed can be entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

The watershed of Rolling Stone Lake is approximately 8,909 acres (Map 2). It is largely dominated by forests (5,974 acres or 67%) with smaller portions consisting of wetlands (24%), the lake surface (8%), and pasture / grass (1%) comprising the rest (Figure 3.2-1). The watershed covers 13 times as much area as Rolling Stone Lake, creating a watershed to lake area ratio of 13:1. This ratio indicates that the size of the watershed may influence the lake in terms of water quality more so than the land types within the watershed.

The land cover surrounding Rolling Stone Lake is that which is very efficient at absorbing nutrients and water, which under these circumstances alone would result in little runoff to the lake. However, because of the large watershed to lake surface area ratio, a large amount of land is contributing water runoff to the lake which naturally increases the input of nutrients to the lake as well. Modeling of phosphorus runoff to Rolling Stone Lake using WiLMS confirms that conclusion. The annual phosphorus load for the lake is estimated to be 876 lbs., a relatively moderate to high amount for a lake of this size. Of the contributing land cover types, forested land exports the most (55% of the annual load) to Rolling Stone Lake, while wetlands and atmospheric deposition on the lake surface contributes 22% and 21%, respectively (Figure 3.1-2). Pasture / grass land, which covers a very small (1%) portion of the watershed, contributes the remaining 2% of the annual load.

Although the phosphorus load entering Rolling Stone Lake is significant, the hydrology of the lake likely assists in keeping nutrient levels in balance within the waterbody. Rolling Stone Lake is classified as a drainage lake. Drainage lakes have both input and output tributaries which influence their hydrology significantly. In fact, Rolling Stone Lake has a relatively high flushing rate of 2.1 times per year, meaning the water in the lake is flushed roughly every 167 days. Along with water, nutrients and sediments are flushed from the lake as well.

The land cover within the Rolling Stone Lake watershed is as beneficial as it possibly could be in terms of protecting the integrity and health of the lake. Despite this, a significant phosphorus load is deposited in the lake every year. Nutrient buildup in a lake is a naturally occurring process (called *eutrophication*), and this process can become accelerated by anthropogenic (human) impacts or disturbances (called *cultural eutrophication*).

Although little can be done to enhance the surrounding Rolling Stone Lake watershed, some benefit would be achieved from protecting and restoring what may be the most critical area of the watershed – the immediate shoreland area. When a lake's shoreline becomes developed, these human disturbances (impervious surface, removal of natural vegetation, installation of septic systems, etc.) can increase the pollutant load to the lake while at the same time degrading important habitat. Keeping these anthropogenic effects to a minimum is likely the best way to discourage the phosphorus load to Rolling Stone Lake from increasing.

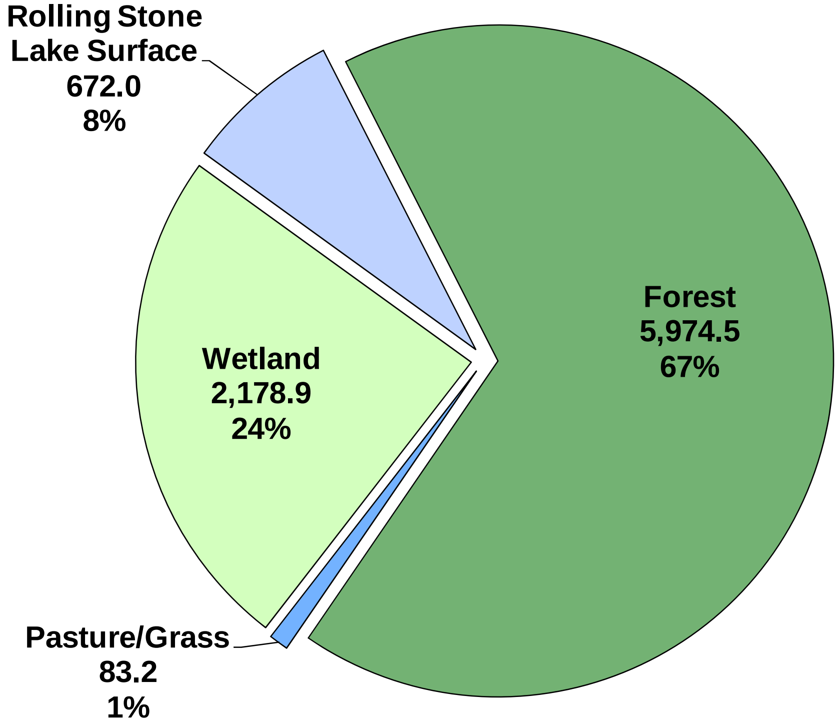

Figure 3.2-1. Rolling Stone Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

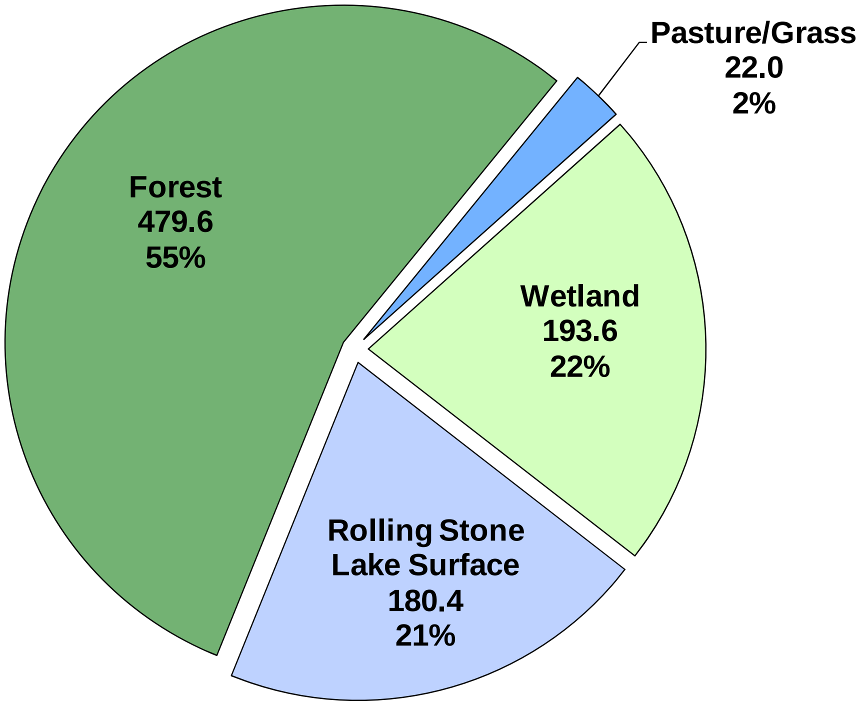

Figure 3.2-2. Rolling Stone Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced numbers of predator fish and a stunted pan-fish population. Exotic plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

> **Important Note:**
> Even though most of these techniques are not applicable to Rolling Stone Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Rolling Stone Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreline. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreline sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,200.

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35’ x 100’.
  - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
  - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.
  - The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	***Disadvantages***
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb *benthic* organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	*Disadvantages*
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	***Disadvantages***
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant affects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and

Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

> Fluridone (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.
>
> Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.
>
> Endothall (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.
>
> 2,4-D (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply.
>
> Triclopyr (Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.
>
> Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a surfactant to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling

purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

Imazapyr (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments.	• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost
Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (*cella* insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost
The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered "safe," reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergents or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Rolling Stone Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Rolling Stone Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

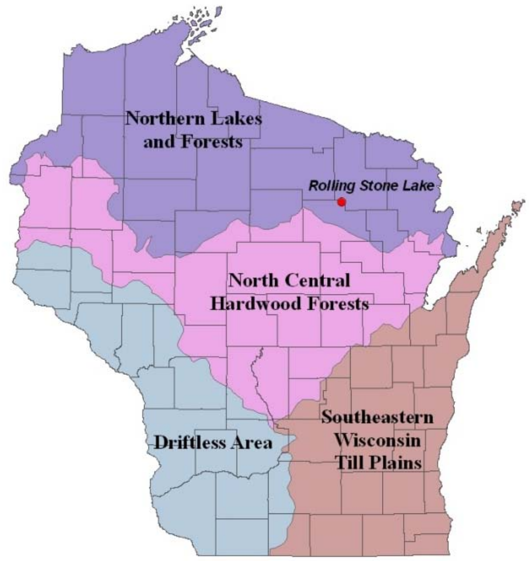

Figure 3.3-1. Location of Rolling Stone Lake within the ecoregions of Wisconsin. After Nichols 1999.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Simpson's diversity index is used to determine this diversity in a lake ecosystem. Simpson's diversity (1-D) is calculated as:

$$D = \sum (n/N)^2$$

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Rolling Stone Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreline. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreline complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreline complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Rolling Stone Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plan surveys.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

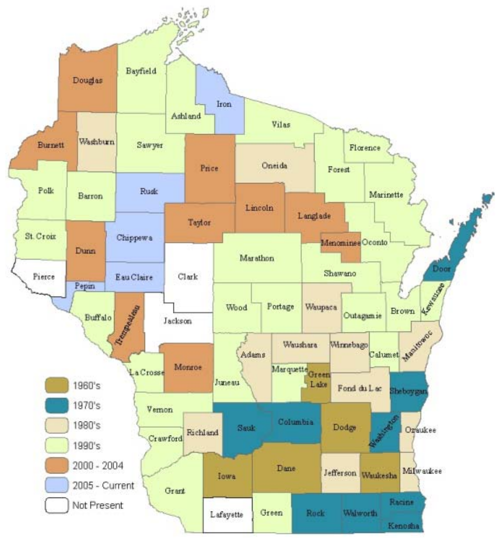

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian water milfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 8th, 2009, a survey was completed Rolling Stone Lake that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed as it may not have existed or was present at undetectable levels. However, in June of 2010, the exotic was spotted in a small area near the Rolling Stone Lake public boat launch by the Lumberjack Invasive Species Coordinator, Chris Hamerla. Onterra confirmed the presence of curly-leaf pondweed several days later, and mapped the extents of this pioneer infestation. More information dealing with the presence of curly-leaf pondweed in Rolling Stone Lake can be found in the Non-Native Plants portion of this section, and also within the Implementation Plan.

The point intercept survey was conducted on Rolling Stone Lake in 2007 by members of the Sokaogon Chippewa Community. Additional surveys were completed by Onterra on Rolling Stone Lake to create the aquatic plant community maps (Map 3) during early August 2009

Between the combined 2007 point-intercept and 2009 aquatic plant mapping survey, 27 species of plants were located in Rolling Stone Lake (Table 3.3-1). 16 of these species were sampled directly during the point-intercept survey and are used in the analysis that follows. As previously mentioned, an additional plant, the invasive curly-leaf pondweed, was discovered in the lake in 2010. Because of its very early stage of infestation within the lake and its implications on the management of this system, curly-leaf pondweed will be discussed in depth in a separate section.

During the surveys, excessive plant growth (native plants matting on the surface) was observed, in some parts of the lake. The high amount of nutrients within the water column, organic substrate, and shallow water probably all contribute to high amounts of plant biomass observed. The results of a stakeholder survey sent to RSLPRD members in 2010 indicate that aquatic plant growth negatively impacts approximately 90% of respondent's enjoyment of the lake (Appendix B, Question #24). 86.5% of respondents indicate that aquatic plant control is needed on the lake, while a little over 2% believe no control is needed and 11% are unsure (Question #25). Only 20 of 157 (12%) stakeholder surveys that answered Question #26 indicated that they were **not** at least moderately supportive of mechanical harvesting occurring on the lake.

Indeed, Rolling Stone Lake is a productive system; during the 2007 point-intercept survey aquatic plants were found at 98% of the 409 sites visited. While aquatic plant growth is abundant and appears to impact recreational activity to a certain extent, it should be noted that stakeholders listed water quality related issues ("Algae blooms", "Water quality degradation/pollution", and "Septic system discharge") to be of greater concern than native plant abundance several times in the survey (Questions #22 and #23).

Table 3.3-1. Aquatic plant species located on Rolling Stone Lake, 2007 and 2009. Species noted during 2007 Sokaogon Chippewa Community point-intercept and 2009 Onterra community mapping surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2007 Sokagon Tribe Species	2009 Onterra Community Mapping Species
E	*Calla palustris*	Water arum	9	-	I
	Eleocharis palustris	Creeping spikerush	6	-	I
	Sagittaria latifolia	Common arrowhead	3	-	I
	Schoenoplectus acutus	Hardstem bulrush	5	I	I
	Typha latifolia	Broad-leaved cattail	1	I	I
	Zizania palustris	Northern wild rice	8	-	I
FL	*Brasenia schreberi*	Watershield	7	-	I
	Nuphar variegata	Spatterdock	6	I	I
	Nuphar advena	Yellow water lily	8	I	
	Nymphaea odorata	White water lily	6	X	I
FL/E	*Sparganium emersum*	Short-stemmed bur-reed	8	-	I
	Sparganium fluctuans	Floating-leaf bur-reed	10	X	
Submergent	*Chara sp.*	Muskgrasses	7	X	
	Ceratophyllum demersum	Coontail	3	X	
	Elodea canadensis	Common waterweed	3	X	
	Heteranthera dubia	Water stargrass	6	X	
	Myriophyllum sibiricum	Northern water milfoil	7	X	
	Potamogeton illinoensis	Illinois pondweed	6	X	
	Potamogeton pusillus	Small pondweed	7	X	
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	
	Potamogeton praelongus	White-stem pondweed	8	X	
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	
	Potamogeton robbinsii	Fern pondweed	8	X	
	Ranunculus aquatilis	White water-crowfoot	8	X	
	Vallisneria americana	Wild celery	6	X	
FF	*Lemna trisulca*	Forked duckweed	6	X	

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

The three most frequently observed species found in Rolling Stone Lake - fern pondweed, flat-stem pondweed, and coontail, are all species that are indicative of productive, eutrophic lakes (Figure 3.3-3). Fern pondweed is usually a low-growing plant that was likely named after its palm-frond or fern-like appearance, while flat-stem pondweed is more versatile in that it may grow low or span several meters of the water column. Coontail was the third most abundant species observed in Rolling Stone Lake. Coontail lacks true root structures and its locations are often subject to water movement and their tendency to become entangled in plants, rocks, or debris. Rolling Stone Lake contains a large amount of submergent plants species which at certain times of the year, can be found growing to the surface and likely provide the substrate needed for coontail to become entangled.

As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while fern pondweed was found at over 80% of the sampling locations in Rolling Stone Lake, its relative frequency of occurrence is 23%. Explained another way, if 100 plants were randomly sampled from Rolling Stone Lake, 23 of them would be fern pondweed. Looking at relative frequency of occurrence (Figure 3.3-4), 10 species comprise approximately 98% of the plant community in Rolling Stone Lake.

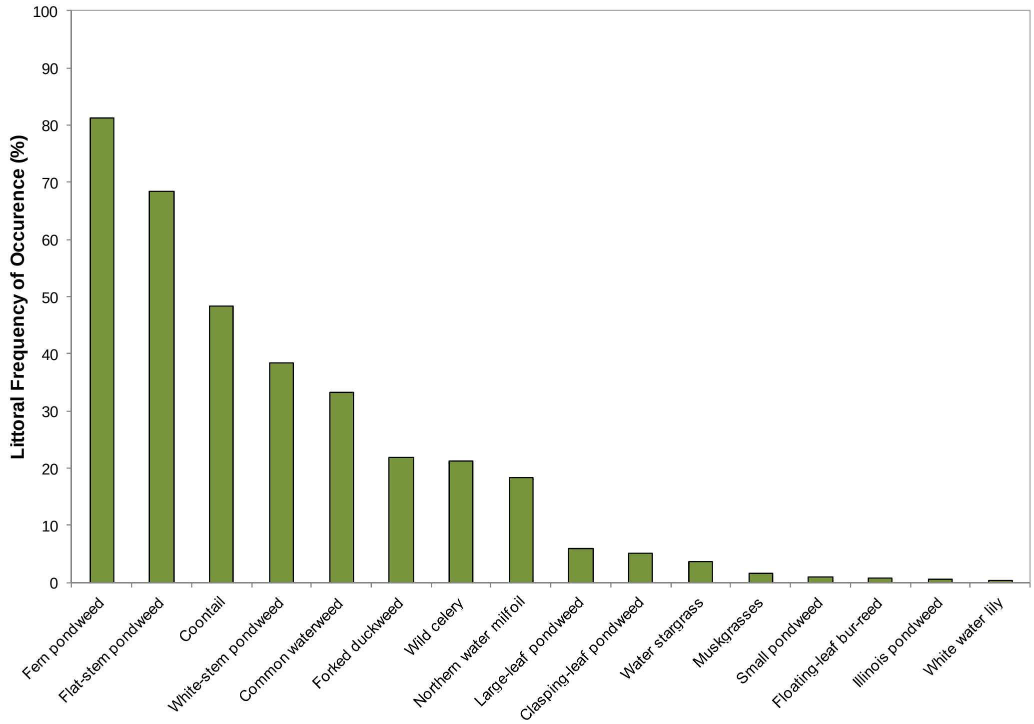

Figure 3.3-3 Rolling Stone Lake aquatic plant littoral frequency of occurrence. Created using data from a 2007 Sokaogon Chippewa Community survey.

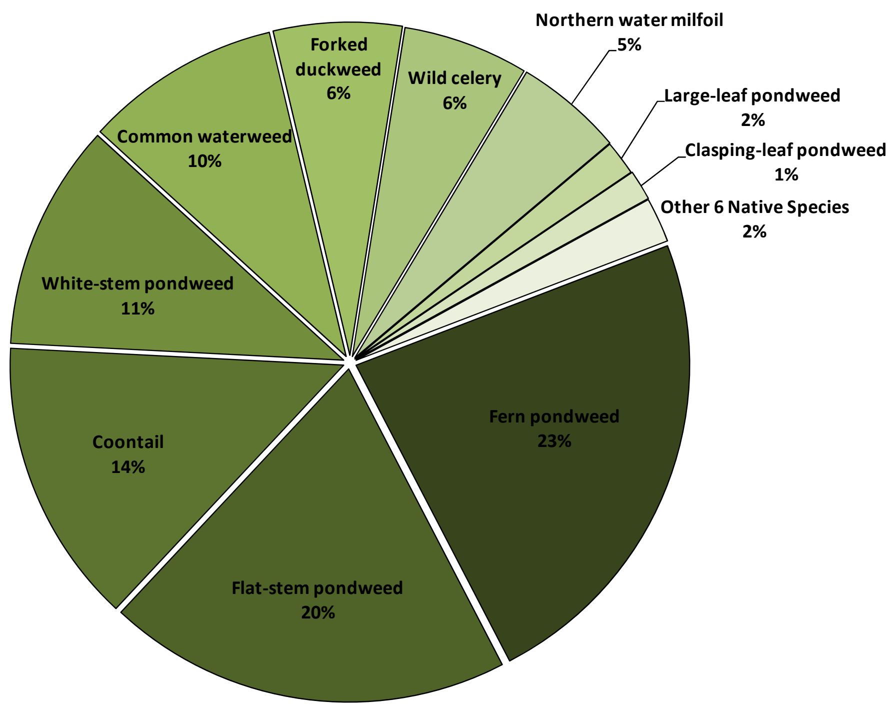

Figure 3.3-4 Rolling Stone Lake aquatic plant relative frequency of occurrence. **C**reated using data from a 2007 Sokaogon Chippewa Community survey.

Data collected from the aquatic plant surveys indicate that the number of native plants in Rolling Stone Lake (utilizing the number of species sampled directly on the point-intercept survey – 16) is higher than the state median and the Northern Lakes Ecoregion median (Figure 3.3-5). In lakes with higher nutrient inputs, like Rolling Stone Lake, the species that are best adapted to access these nutrients directly from the water, like coontail, out-compete other species for space and light. Data collected from the aquatic plant surveys was used to calculate the average conservatism value (6.3) for Rolling Stone Lake. This value is lower than the Northern Lakes Ecoregion Median but slightly higher than the state median (Figure 3.3-5), indicating that the majority of Rolling Stone Lake's plant community is composed of species that are somewhat tolerant to disturbance. Combining the lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a moderately high value of 25.3 (equation shown below), which is above the median values of the state and ecoregion (Figure 3.3-5).

$$FQI = \text{Average Coefficient of Conservatism } (6.3) * \sqrt{\text{Number of Native Species } (16)}$$
$$FQI = 25.3$$

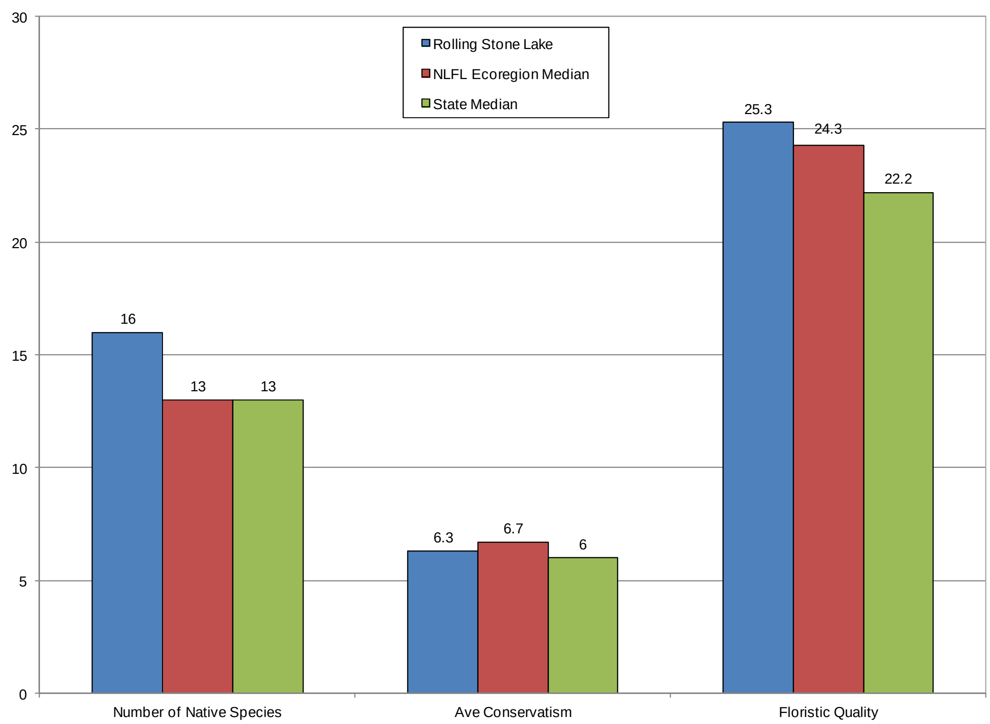

Figure 3.3-5. Rolling Stone Lake Floristic Quality Assessment. Created using data from a 2007 Sokaogon Chippewa Community survey. Analysis following Nichols (1999).

Because Rolling Stone Lake contains a high number of native aquatic plant species, one may assume their aquatic plant communities have high species diversity. However, as discussed earlier, species diversity is also influenced by how evenly the plant species are distributed within the community.

The aquatic plant community in Rolling Stone Lake was found to be fairly diverse, with a Simpson's diversity value of 0.86 (Figure 3.3-6). This value ranks above state and equal to ecoregion median values. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

This quality is also indicated by the high incidence of emergent and floating-leaf plant communities, particularly along the northern shoreline. The 2009 community map indicates that approximately 31.6 acres (4.7%) of the 672-acre lake contains these types of plant communities (Table 3.3-2, Map 3). Ten native floating-leaf and emergent species were located on Rolling Stone Lake, including northern wild rice (Table 3.3-1). Wild rice is of ecological and cultural importance, especially for the Native American community.

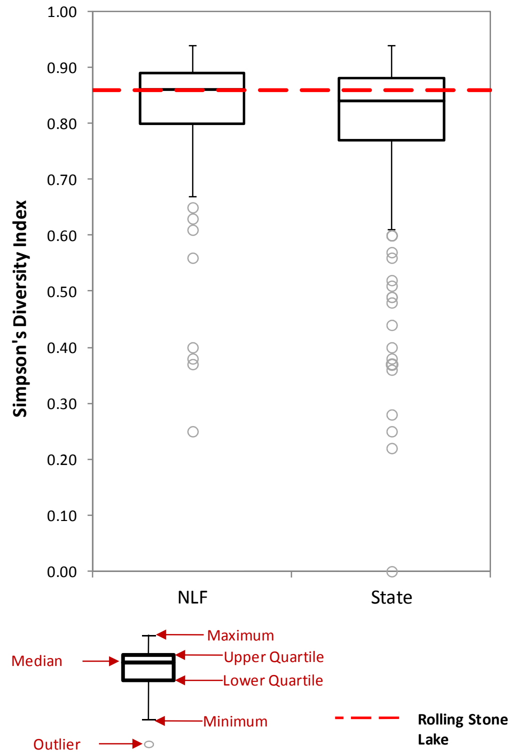

Figure 3.3-6. Rolling Stone Lake species diversity index. Created using data from a 2007 Sokaogon Chippewa Community survey. Ecoregion data provided by WDNR Science Services.

Table 3.3-2 Rolling Stone Lake acres of plant community types from a 2009 survey.

Plant Community	Acres
Emergent	1.3
Floating-leaf	27.3
Mixed Floating-leaf and Emergent	3.0
Total	31.6

Continuing the analogy that the community map represents a 'snapshot' of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Rolling Stone Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Non-native Aquatic Plants – Curly-leaf Pondweed

Curly-leaf pondweed was first documented in Rolling Stone Lake during 2010, and is of particular concern when found growing in any lake, but even more when the lake in question uses mechanical harvesting to control nuisance native plant levels as this practice can potentially accelerate the exotic's spread. Curly-leaf pondweed primarily reproduces annually via structures called turions (asexual reproductive shoots). The majority of the turions are produced along the stem in the leaf axils and fall to the bottom of the lake in late summer when the plants die back. However, some turions are produced lower on the plant and along the underground rhizome. Harvesting areas of curly-leaf pondweed during this period can potentially scatter these turions to other areas of the lake creating new colonies. Additionally, there is a growing amount of evidence that point to this invasive plant producing more underground rhizomes turions when it is stressed (such as when a harvester attempts to remove the plant. As described in the Implementation Plan, harvesting activities should not occur in areas that contain or are suspecting of containing curly-leaf pondweed.

Following the discovery of curly-leaf pondweed in 2010 (Map 4), a conditional herbicide treatment permit was created during winter of 2011 and scheduled for spring 2011. An area of slightly under one acre was proposed. However, during pre-treatment surveys, little curly-leaf pondweed was observed by Onterra ecologists. Following discussion between Onterra, the RSLPRD and WDNR, it was decided that the RSLPRD would forgo an herbicide treatment in favor of continued monitoring. Additionally, RSLPRD would team with the WDNR and Lumberjack Aquatic Invasive Species Coordinator Chris Hamerla to learn monitoring, identification, and hand-removal techniques. Nine RSLPRD members met with Mr. Hamerla in April 2011. Mr. Hamerla presented a slide show on aquatic invasive species, and led the nine volunteers through identification steps using a curly-leaf pondweed plant that he collected from Rolling Stone Lake. Additionally, hand-removal and monitoring techniques were discussed.

In late April of 2012, known areas of curly-leaf pondweed growth were visited by Onterra ecologists once again. One clump of curly-leaf pondweed was observed, occurring within the 2011 proposed treatment area. Onterra ecologists carefully removed this clump (roughly eight plants) from the area.

At this time, curly-leaf pondweed is not significantly impacting the health of Rolling Stone Lake. Furthermore, while some Wisconsin lakes hold infestations of this plant which require herbicide treatments to bring under control, the infestation on Rolling Stone Lake is nowhere near this point. The Implementation Plan includes a strategy for continued monitoring of the lake for this invasive plant.

Aquatic Plant Mechanical Harvesting

The RSLPRD operates a mechanical harvester on Rolling Stone Lake to remove nuisance conditions of native aquatic plant growth. From 2005-2010, about 1,198 harvester loads of aquatic plants have been removed from Rolling Stone Lake, resulting in about 10,183,000 lbs of biomass (assuming a load weight of 8,500 lbs.). Map 5 displays the approximate areas of harvesting activities on Rolling Stone Lake. Figure 3.3-7 summarizes harvesting efforts during this time period, while Table 3.3-3 displays the approximate acreage of each harvesting site located on Map 5.

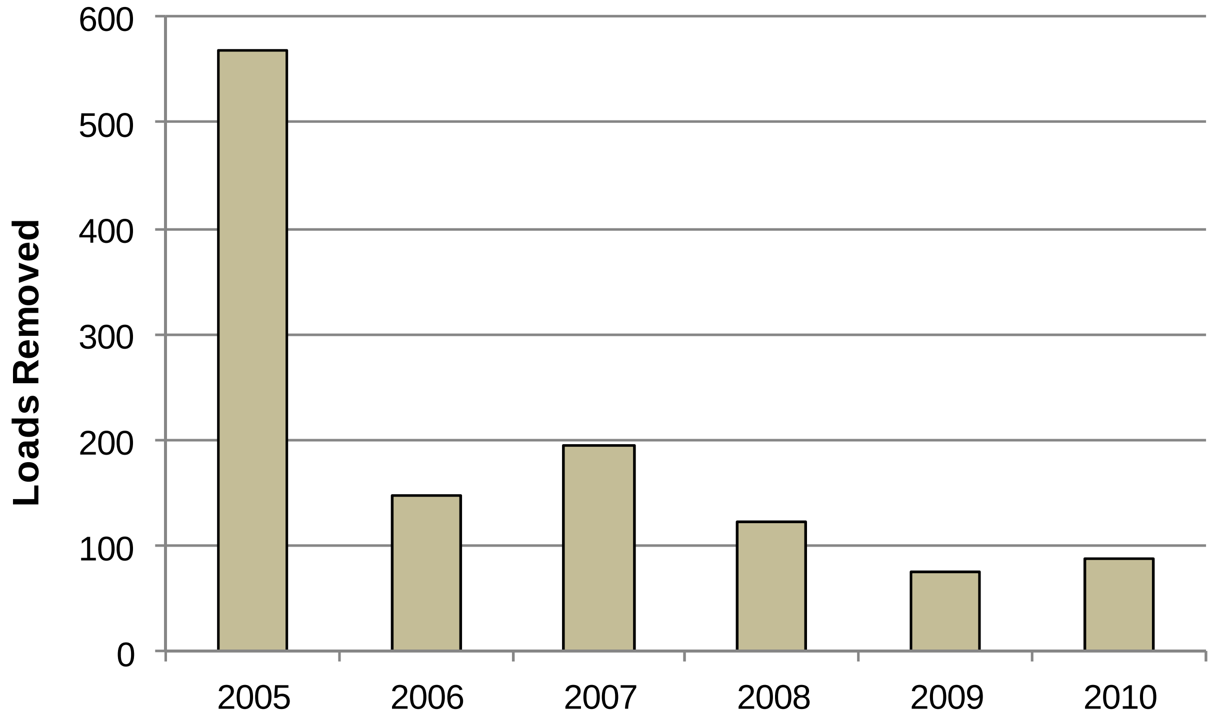

Figure 3.3-7. Rolling Stone Lake mechanical harvesting activities. Created using data provided by Sonny Wreczycki, 2011.

Table 3.3-3 Rolling Stone Lake harvesting site acreage. Approximate location of harvesting sites are displayed on Map 5.

Site	Acres (approximate)
Site 1	6.3
Site 2	21.6
Site 3	12.3
Site 4	20.0
Site 5	13.6
Site 6	40.9
Site 7	19.8
Total	134.6

As discussed above, utilizing a mechanical harvester in known areas of curly-leaf pondweed growth is not advised. In fact, having a robust native aquatic plant population would be beneficial in keeping curly-leaf pondweed from expanding within the lake. The Implementation Plan contains a further strategy and stipulations for mechanical harvesting on Rolling Stone Lake.

3.4 Rolling Stone Lake Fishery

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Rolling Stone Lake. The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the RSLPRD stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2010 & GLIFWC 2010A and 2010B).

Table 3.4-1. Gamefish present in the Rolling Stone Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other inverts
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Walleye	Sander vitreus	18	Mid April - Early May	Rocky, wave-washed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Rolling Stone Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on Rolling Stone Lake (Question #16). Approximately 79% of these same respondents believed that the quality of fishing on the lake was either fair or good (Question #8); however approximately 88% believe that the quality of fishing has remained the same or gotten worse since they began fishing the lake (Question #9).

By several accounts, Rolling Stone Lake has historically been a fertile lake, producing native aquatic plants at nuisance levels in the littoral areas of the lake. 90% of respondents in the 2009 stakeholder survey stated that aquatic plant growth sometimes or always impacts their enjoyment of the lake, and 98% believe aquatic plant control is needed in the lake (Questions #24 and #25). Table 3.4-1(above) shows the popular game fish and that are present in Rolling Stone Lake. With all actions that are taken to address plant growth in Rolling Stone Lake, it will be important to understand the potential impacts they will have on the fish community and plan their implementations accordingly. Specifically, the alteration of these elements may impact spawning habitat for fish species. Yellow perch is a species that could potentially be affected by early season plant management, as this could eliminate nursery areas for the emerged fry of these species. When aquatic plants are controlled utilizing a mechanical harvester, as has been done on Rolling Stone Lake in years past, a general rule of thumb is to begin harvesting after June 1st, which would allow the vast majority of fish species to complete their spawning season.

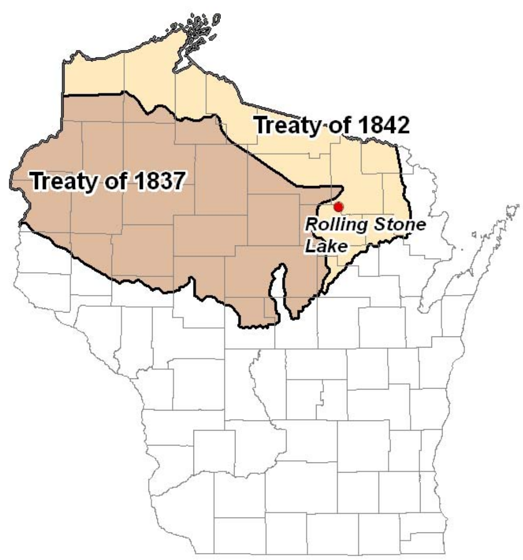

Figure 3.4-1. Location of Rolling Stone Lake within the Native American Ceded Territory (GLIFWC 2011). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Rolling Stone Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

A walleye spear harvest has happened in only 3 of the 10 years on record (Table 3.4-2 and Figure 3.4-2). In these three years, the harvest has remained below the declared quota for that particular year. In 2006, the harvest reached its highest at 46% of the declared quota. However in the other 2 years in which a harvest occurred, the catch remained below 10% of the quota.

One common misconception noted from the stakeholder survey (Appendix B – Written Comments) is that the spear harvest targets the large spawning females. In fact, of the 41 total fish speared from 1998-2009, all were male and two fish were not able to be sexed (Table 3.4-2). Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2011). This regulation limits the harvest of the larger, spawning female walleye.

Because Rolling Stone Lake is located within ceded territory, special fisheries regulations may occur. In all ceded territory counties, muskellunge minimum length limit is 34” with a daily bag limit of 1 fish. For walleye, the minimum length limit is 18” with a daily bag limit of 3. Additionally, motor trolling is permitted on Rolling Stone Lake.

Table 3.4-2. Spear harvest data of walleye for Rolling Stone Lake (GLIFWC annual reports for Rolling Stone Lake, Krueger 1998-2009).

Year	Quota	Total	% Quota	Mean Length* (in)	% Male*	% Female*	% Unknown*
1998	64	0	0	-	-	-	-
1999	59	0	0	-	-	-	-
2000	63	0	0	-	-	-	-
2001	64	0	0	-	-	-	-
2002	66	6	9	22.4	100	0	0
2003	68	0	0	-	-	-	-
2004	69	0	0	-	-	-	-
2005	67	4	6	19	75	0	25
2006	67	31	46	18.4	97	0	3
2007	45	0	0	-	-	-	-
2008	69	0	0	-	-	-	-
2009	68	0	0	-	-	-	-

*Based on Measured Fish

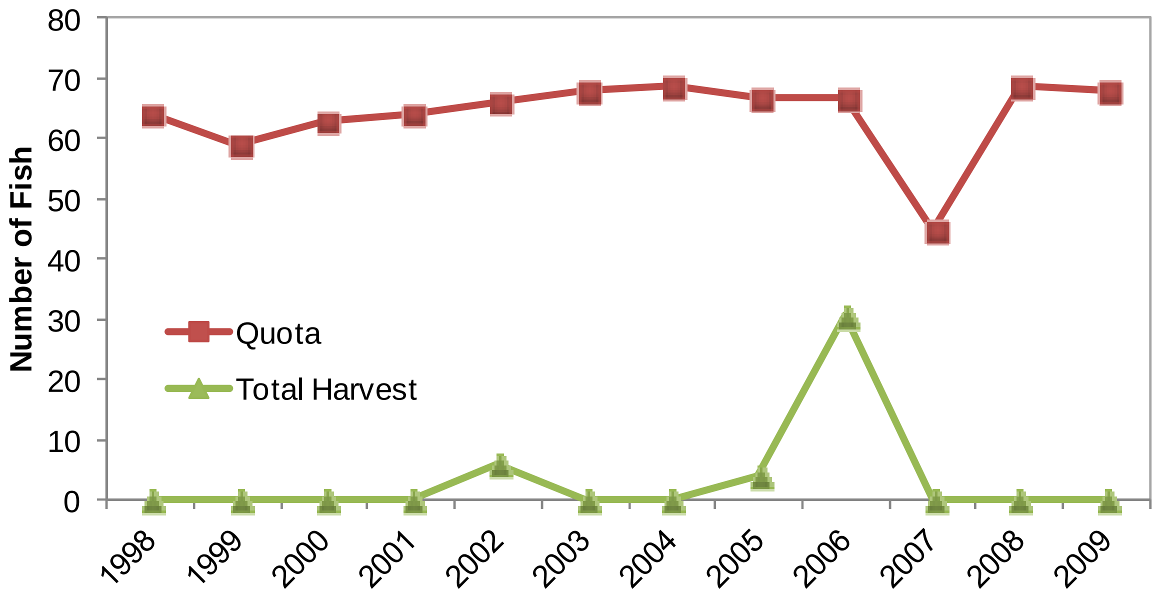

Figure 3.4-2. Walleye spear harvest data. Annual total walleye harvest and female walleye harvest are displayed since 1998 from GLIFWC annual reports for Rolling Stone Lake (Krueger 1998-2009).

Rolling Stone Lake Fishery Management

Walleye were stocked actively in past years by the WDNR (Table 3.4-3) in an effort to influence the populations of these species and to hopefully establish a fishery in Rolling Stone Lake. However WDNR fall electroshocking surveys from 2002-2005 turned up no age 0 or age 1 walleyes and only 2 adults. After decades of walleye stocking, there was very low survival of these fish and the lake had failed to produce a viable fishery. It was then decided by the fisheries biologists that stocking of walleye should discontinue in the lake.

Dave Seibel of the WDNR stated that Rolling Stone Lake is now being managed for bass, northern pike and panfish. The lake has a very good fishery, and also has the proper habitat for these species. The lake is scheduled for a full comprehensive fish survey in 2012, which will include surveys such as an ice-out fyke netting, spring/early summer electrofishing of the entire shoreline, late May/early June panfish fyke netting, and potentially 1 night of fall shoreline electrofishing. These surveys should produce a wealth of information which will help WDNR biologists guide future management decisions.

Table 3.4-3. Stocking data available from the WDNR from 1966 to 2003 (WDNR 2010).

Year	Species	Age Class	Number Stocked	Avg. Fish Length (in)
1966	Walleye	-	20,425	-
1969	Walleye	-	30,600	-
1971	Walleye	-	15,000	-
1972	Walleye	Fingerling	7,350	5
1973	Walleye	Fingerling	20,000	5
1974	Walleye	Fingerling	70,299	4.5
1976	Walleye	Fingerling	32,250	3
1978	Walleye	Fry	1,500,000	NA
1979	Walleye	Fingerling	20,000	5
1979	Walleye	Fry	1,000,000	NA
1981	Walleye	Fingerling	33,550	3
1983	Walleye	Fingerling	35,550	3
1985	Walleye	Fingerling	33,555	3
1987	Walleye	Fingerling	65,100	4
1989	Walleye	Fingerling	4,191	3
1989	Walleye	Fry	29,337	2
1991	Walleye	Fingerling	33,558	2
1993	Walleye	Fingerling	30,124	2
1995	Walleye	Fingerling	33,634	1.9
1996	Largemouth Bass	Fingerling	33,500	1.4
1996	Walleye	Fry	350,000	0.3
1999	Walleye	Small fingerling	67,200	1.5
2001	Walleye	Small fingerling	67,200	1.7
2003	Walleye	Small fingerling	67,200	1.4

As discussed within the Water Quality Section, Rolling Stone Lake, due to its shallow and productive nature, is prone to low winter dissolved oxygen levels. WDNR fisheries biologists know that partial winter kills occur in Rolling Stone Lake most winters, however, there is a belief that these winterkills may actually be helping the fishery by lessening the food bottleneck and corresponding stunted growth that is seen on many other lakes. Indeed, from WDNR observations most of the minor winterkills that have been observed on the lake have involved small panfish, and occasional larger fish. "Refuge" areas such as the inlets of creeks to the lake likely replenish the surrounding water with dissolved oxygen.

While WDNR fisheries biologists are not overly concerned about the fishery and winter oxygen levels of Rolling Stone Lake, they have acknowledged it as a potential threat and will continue to collect information regarding the fishery. A comprehensive survey, which includes early spring, late May/early June and fall sampling efforts was scheduled for 2012 to assess the fishery.

Rolling Stone Lake Substrate Type

According to the 2007 point-intercept survey conducted by the WDNR, 96% of the substrate sampled in the littoral zone on Rolling Stone Lake was muck, 3% classified as sand, and the remaining 1% as rock (Map 10). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so they do not get buried in sediment and suffocate. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three objectives;

1) To learn whether exotic plants occur within Rolling Stone Lake,
2) To formulate an ecologically sound harvesting program that meets stakeholder's interests,
3) To gain a better understanding of the lake ecosystem.

The three objectives were fulfilled during the project and have led to a good understanding of the Rolling Stone Lake ecosystem, the folks that care about the lakes, and what needs to be completed to protect and enhance them.

There is no denying that Rolling Stone Lake is very productive. The lake has a fairly large watershed, which drains over 8,900 acres of forests and wetlands primarily. Water from the watershed enters Rolling Stone Lake through several inlets, providing the lake with more nutrients every year. Total phosphorus concentrations within the water column are higher than lakes found within the northeast region of Wisconsin and across the state, however not by much. Algae content within the water column appears to fluctuate much annually. Lake residents have likely noticed this, as water conditions may be drastically different from year to year. Not surprisingly, Secchi disk clarity varies dramatically on an annual basis also, as the clarity of the water is tied highly to algal content. It must be remembered that Rolling Stone Lake is a very dynamic ecosystem that is influenced heavily by environmental conditions. The lack of stable conditions can be somewhat of a nuisance for lake stakeholders; however, these fluctuations are beneficial in the long run for the ecosystem and quite fascinating from a scientific perspective.

The abundant nutrients within Rolling Stone Lake help to produce a rich and diverse aquatic plant community. These aquatic plants benefit the lake ecosystem in many ways. First, the plants provide beneficial habitat for organisms such as insects, zooplankton, and fish. Some species of plants are a preferred by waterfowl and other shoreland birds as a source of food, cover from predators, and habitat for laying eggs, etc. A diverse plant community only increases the value for these animals. Secondly, the healthy aquatic plant community is likely the reason curly-leaf pondweed has not spread rapidly throughout the lake ecosystem. It becomes difficult for an invasive plant to establish itself within a lake if the amount of available habitat is limited. When submersed native plants grow in abundance, their long stems and leaves reduce the spread of invasive plant fragments or turions with the lake. This may be the reason that curly-leaf pondweed was found to only exist in a small, isolated area in Rolling Stone Lake.

The presence of a strong native aquatic plant community helps to keep clear water within the lake as well. Shallow, productive waterbodies typically fall into one of two categories: *clear-state* and *turbid-state* lakes. Clear-state lakes are characterized by having clear water, yet enough nutrients to produce abundant vegetation. The vegetation provides cover to microscopic animals called zooplankton that graze upon algae much as a cow grazes upon grass. The vegetation also reduces nutrient and light availability for algae as well. Once the aquatic plants are removed, the zooplankton are left uncovered and are preyed upon heavily by fish. Plus, the nutrients once used by the plants are now available for algae. Turbid-state lakes may have the same amount of nutrients within them; however, it is algae that utilize these nutrients. As a result, the water becomes turbid and vegetation is relatively sparse. These two states are "stable" in that the lake will persist in this way until a disturbance shifts the system from one state to the other.

Although the healthy aquatic plant community produces many positive attributes, the overabundant vegetation can become a nuisance for stakeholders trying to navigate through the lake. The strategic use of a mechanical harvester is beneficial because it allows removal of vegetation from some of the densest areas of the lake, without impacting the overall plant community. Harvesting operations, used sparingly and in designated areas, will not result in a shift from a clear-state to a turbid-state lake. However, one danger of harvesting operations is the potential to spread curly-leaf pondweed throughout Rolling Stone Lake. To reduce the chance of this occurring, it is vital that this AIS be monitored on an annual basis, and known locations of the plant to be flagged by physical or geospatial means. If this is done prior to harvesting operations, the harvester may avoid these areas and thus not potentially spread the plant and its turions to a new location. The Implementation Plan contains specific details regarding mechanical harvesting on Rolling Stone Lake.

Regarding the lake's health, its aquatic plants, and mechanical harvesting; the most important fact that Rolling Stone Lake stakeholders need to remember is that the health of the lake does not depend on mechanical harvesting operations. In other words, harvesting does not need to occur to keep Rolling Stone Lake healthy. At the levels at which harvesting is currently conducted, the health of the lake is likely not impacted; however, if increased harvesting is sustained, the lake's health could be impacted by decreasing the frequency of important plant species and by increasing the frequency of exotics, such as curly-leaf pondweed.

Right now, probably the most pressing threat to Rolling Stone Lake may be the discovery of curly-leaf pondweed within the lake. In a productive system that has the capacity to produce many other pondweed species, it can be said that Rolling Stone Lake likely has the right environment to potentially grow large communities of curly-leaf pondweed also. Once the plant expands into colonies that span an acre or more in area, it is very difficult to control as there is a larger source population for turion production. When curly-leaf pondweed infestations reach this level, spring herbicide treatments must occur in order to kill the plants before they produce turions, which would otherwise sprout future plants. Unfortunately however, once an infestation has reached this level there may be several years of turion accumulation within the sediments of the lake. As a result, herbicide treatments or other control actions may be required for many years in a row to deplete this turion base.

Fortunately, the infestation has been discovered in its very early stages, and direct action has taken place to monitor and manually remove the plant. The Implementation Plan contains a strategy for continued monitoring of this invasive plant, which the RSLPRD has already initiated and committed to in order to protect their lake.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a comprehensive management plan for Rolling Stone Lake. As described in the proceeding sections, a great deal of study and analysis were completed involving many aspects of the Rolling Stone Lake ecosystem. This section stands as the actual "plan" portion of this document as it outlines the steps the Rolling Stone Lake Protection and Rehabilitation District will follow in order to manage Rolling Stone Lake, its watershed, and the district itself.

The implementation plan is broken into individual Management Goals. Each management goal has one or more management actions that if completed, will lead to the specific management goal in being met. Each management action contains a timeframe for which the action will be taken, a facilitator that will initiate or carry out the action, a description of the action, and if applicable, a list of prospective funding sources and specific actions steps.

Management Goal 1: Maintain Current Water Quality Conditions

Management Action: Continue to monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe Continuation of current effort.

Facilitator: RSLPRD Planning Committee

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing. Volunteers from the RSLPRD have been collecting Secchi disk clarities and water chemistry samples through the WDNR Citizens Lake Monitoring Program for quite some time. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes. It is the responsibility of the Planning Committee to coordinate new volunteers as needed. Note: as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

Management Action: Complete shoreland condition assessment as a part of next management plan update.

Timeframe: Begin with management plan update

Facilitator: Board of Directors

Description: As discussed above, unnatural shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other aquatic species that reside within the lake. Understanding the shoreland conditions around Rolling Stone Lake will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of course woody debris, a fisheries habitat component lacking around the shores of Rolling Stone Lake. Shoreline enhancements would include leaving 30-foot no-mow zones or by planting native herbaceous, shrub, and tree species as appropriate for Langlade County.

Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program.

Action Steps: See description above.

Management Goal 2: Maintain Public Access to Rolling Stone Lake

Management Action: Support reasonable and responsible actions by shoreland property owners to gain navigational access to open water areas of Rolling Stone Lake

Timeframe: Begin 2013

Facilitator: RSLPRD Board of Directors

Description: As previously stated within the Aquatic Plant Section, over 90% of respondents in a 2009 stakeholder survey responded that aquatic plant growth impacts their enjoyment of Rolling Stone Lake to a certain degree (Appendix B, Question #24). 87% of these respondents indicated that they were supportive of aquatic plant control efforts on the lake, with 11% being unsure (Question # 25). The majority of Rolling Stone Lake stakeholders are supportive of mechanical harvesting actions on the lake (Question #26). The RSLPRD has been operating a mechanical harvester to clear excessive submersed aquatic vegetation as well as floating vegetation from the lake for some time. These efforts have targeted nuisance levels of native aquatic plants in order to restore watercraft access to open water areas of the lake.

Map 5 indicates the approximate areas where harvesting has occurred in the past. Within these locations, the conditions are optimal for aquatic plant growth, and the submersed plants here often reach the water's surface, impacting navigation. Additionally, these plants collect unrooted floating species such as coontail, which obstructs navigation even more so.

The RSLPRD wishes to continue reasonable and environmentally sound mechanical harvesting operations to ensure watercraft access throughout the lake Reasonable and environmentally sound actions are those that meet WDNR regulatory and permitting requirements and do not impact shoreland or lake surface area. The WDNR will issue a permit to the RSLPRD, which will include stipulations based upon their Aquatic Plant Management Strategy (Northern Region WDNR, Summer 2007).

While Map 5 displays the intended harvesting locations on Rolling Stone Lake, the harvester operator must be conscientious of their harvesting practices within these areas, and be prepared to navigate around areas that harvesting activities must not contact. For example, many emergent and floating-leaf communities exist on Rolling Stone Lake. These areas serve as valuable wildlife and aquatic life habitat, in addition to buffering the shoreland area from wave action. Harvesting should not be conducted in these areas as this action would remove these beneficial plants. Also, a non-native species, curly-leaf pondweed, is known to be found within the lake. Known occurrences of this aquatic plant should be avoided, as harvesting the plant could unknowingly result in transport of its reproductive turions to other areas of the lake. Occurrences of curly-leaf pondweed may be documented prior to harvesting operations through volunteer-based monitoring activities (See Management Goal 4).

Action Steps:

1. Contact Kevin Gauthier, WDNR (715-365-8937), regarding permit applications for harvesting activities.
2. The RSLPRD harvests in areas shown on Map 5 while following conditions listed on WDNR permit.
3. Harvest summary report is provided to the WDNR annually after each harvesting season.

Management Goal 3: Prevent Introduction and Establishment of Aquatic Invasive Species within Rolling Stone Lake

<u>Management Action:</u> Continue Clean Boats Clean Waters watercraft inspections at Rolling Stone Lake public access.

Timeframe: In progress

Facilitator: RSLPRD Board of Directors

Description: Volunteers from Rolling Stone Lake have monitored the public access point in 2008, 2010 and 2011 through the state's Clean Boats Clean Waters program. While the group's efforts are important in reducing the likelihood that AIS such as Eurasian water milfoil are introduced to the lake, there is now greater importance in ensuring that curly-leaf pondweed is not transported out of Rolling Stone Lake and into a lake elsewhere.

Most lake groups aim their Clean Boats Clean Waters inspections towards holidays or other busy weekends throughout the open-water months. However, Rolling Stone Lake is a well-known fishing destination and thus receives considerable boat traffic during the week as well. An inspection program aimed at the most busy weekends of the year in addition to many weekdays would be an ideal strategy for watercraft inspections by volunteers from Rolling Stone Lake. This, of course, would depend upon volunteer availability. If necessary, the RSLPRD may elect to hire someone which would spend a pre-determined number of hours monitoring the Rolling Stone Lake public access.

Action Steps:

1. Members of Association attend Clean Boats Clean Waters training
2. Training of additional volunteers completed by those trained.
3. Begin inspections during high-risk weekends and during the week
4. Report results to WDNR and RSLPRD.
5. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Initiate volunteer-based monitoring of aquatic invasive species.
Timeframe: In progress
Facilitator: Invasive Species Committee
Description: In lakes with aquatic invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. Using trained volunteers is a feasible method to monitor for the occurrence of these unwanted species. The keys to success are proper training and persistence by the lake group.

In April of 2011, nine RSLPRD members met with Lumberjack Aquatic Invasive Species Coordinator Chris Hamerla to learn monitoring, identification, and hand-removal techniques. Since then, Chris Hamerla has taken a new position and John Preuss has been hired as the new Lumberjack Aquatic Invasive Species Coordinator. Volunteers from Rolling Stone Lake should contact Mr. Preuss (715-369-9886) to introduce the RSLPRD and familiarize him with the group and their efforts. Mr. Preuss should also be contacted on a regular basis to ensure that the RSLPRD volunteers are updated on all aspects of AIS monitoring including identification, monitoring techniques, etc.

A special note on volunteer survey timing: As previously stated in Management Goal 2, persons operating the mechanical harvester on Rolling Stone Lake should take care to avoid known areas of curly-leaf pondweed. Therefore, volunteer surveys should be conducted in June, prior to the beginning of harvesting activities. Furthermore, this information needs to be relayed to the harvester operator(s). This way, the harvester operator will have knowledge of where exotic plants such as curly-leaf pondweed exist, and will be able to avoid these areas.

Action Steps:

1. Volunteers from RSLPRD attend training session conducted by WDNR, UW-Extension, or Lumberjack AIS Coordinator.
2. Trained volunteers recruit and train additional District members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and RSLPRD.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Rolling Stone Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point on the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected using WDNR Citizen Lake Monitoring Network (CLMN) protocols which occurred once in spring and three times during the summer. In addition to the samples collected by RSLPRD members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although RSLPRD members collected a spring total phosphorus sample, professionals also collected a near bottom sample to coincide with the bottom total phosphorus sample. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle. Secchi disk transparency was also included during each visit.

All samples that required laboratory analysis were processed through the Wisconsin State Laboratory of Hygiene (SLOH). The parameters measured, sample collection timing, and designated collector are contained in the table below.

	Spring		June	July	August	Fall		Winter	
Parameter	**S**	**B**	**S**	**S**	**S**	**S**	**B**	**S**	**B**
Total Phosphorus	■♦	■	♦	♦	♦	■	■	■	■
Dissolved Phosphorus	■	■						■	■
Chlorophyll-*a*	■		♦	♦	♦	■			
Total Kjeldahl Nitrogen	■	■	●	●	●	■		■	■
Nitrate-Nitrite Nitrogen	■	■	●	●	●	■		■	■
Ammonia Nitrogen	■	■	●	●	●	■		■	■
Laboratory Conductivity	■	■							
Laboratory pH	■	■							
Total Alkalinity	■	■							
Total Suspended Solids	■	■				■	■	■	■
Calcium	■								

♦ indicates samples collected as a part of the Citizen Lake Monitoring Network.
● indicates samples collected by volunteers under proposed project funding
■ indicates samples collected by consultant under proposed project funding

The diamond shape indicates samples collected as a part of the Citizen Lake Monitoring Network and the circle indicates samples collected under the proposed project funding. The winter samples were collected by Onterra. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were conducted on Rolling Stone Lake on June 8, 2009 during field visits, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat. No colonies were spotted during this survey, however in June of 2010 Onterra staff paid a visit to the lake to look for reported curly-leaf pondweed plants. These small areas were identified and mapped utilizing a Trimble GPS with sub-meter accuracy

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Rolling Stone Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in “Appendix C” of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2008) was used to complete this study on August 28 through September 3, 2007 by the Sokaogon Chippewa Community. A point spacing of 82 meters was used resulting in approximately 409 points. The data presented here has been analyzed by Onterra staff.

Community Mapping

On August 4, 2009, the aquatic vegetation community types within Rolling Stone Lake (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Watershed Analysis

The watershed analysis began with an accurate delineation of Rolling Stone Lake’s drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR’s Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003).

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